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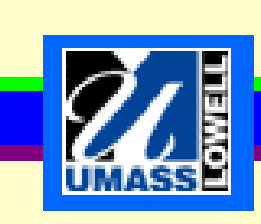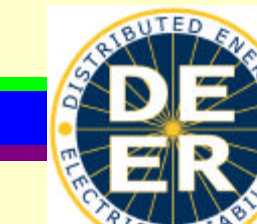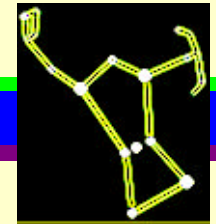# DISTRIBUTED ENERGY NEURAL NETWORK INTEGRATION SYSTEM

DENNIS®
distributed energy neural network integration system

Why DENNIS® and Why Now?

"We foresee a world of cleaner, smaller and more efficient units of power generation. We foresee more individual choice, more competition, and a closer approximation of a true market for energy in America. And we foresee increased reliability, increased supply, and lower prices."

Energy Secretary Spencer Abraham, July 26, 2001

DENNIS® provides the distributed intelligence needed to aggregate and dispatch large numbers of small DER. Through an integration strategy based on discretionary control, DER owners retain operational control at all times.

DISTRIBUTED ENERGY = ENERGY SECURITY

Bulk Integration of DER

Integration of small numbers of DER is traditionally accomplished using simple on/off electronic controls or verbal requests to the DER owner.

This is not possible when DER scales to hundreds or thousands of units.

DENNIS® based distributed intelligence provides an effective scaleable solution for large scale integration.

Distributed intelligence located with the DER makes economic decisions based on the best financial interest of the DER owner.

Distributed intelligence provides a more **secure** and **robust** bi-directional grid.

Neurofuzzy logic learns and adapts to changing generation and usage patterns for optimal dispatch.

Intelligent controller can act in proactive manner to stabilize real-time demand.

DENNIS® uses real-time pricing linked to demand ensuring fair pricing and encouraging generation at proper times.

Leydenborough, NH

The Solution: DENNIS®

Uses neural networks and fuzzy logic to determine the best method to maximize the benefits to the generator, rather than the central utility.

Monitors weather, load, demand, market price and generation capacity.

Capable of optimizing to a **single user** or to a larger **group of users** utilizing real-time pricing.

Enhances power quality and enables cost-effective, remote dispatch and coordination of aggregated DER.

Provides ancillary benefits including voltage support and stability, contingency reserves, and black start capability.

Captures the full value of DER

DENNIS® manages generation dispatch, not load!

Lowell, MA

The DENNIS® Project

3-year project to develop a controller for small DER

Demonstrate the ability for a large group of neural network controllers to economically operate DER.

Provide technologically sophisticated yet simple solution requiring little or no user interaction.

Aggregates an extended community of small DER into a virtual generator capable of selling power in a coordinated manner.

Result - Scaleable energy integration product for residential, commercial and industrial DER applications.
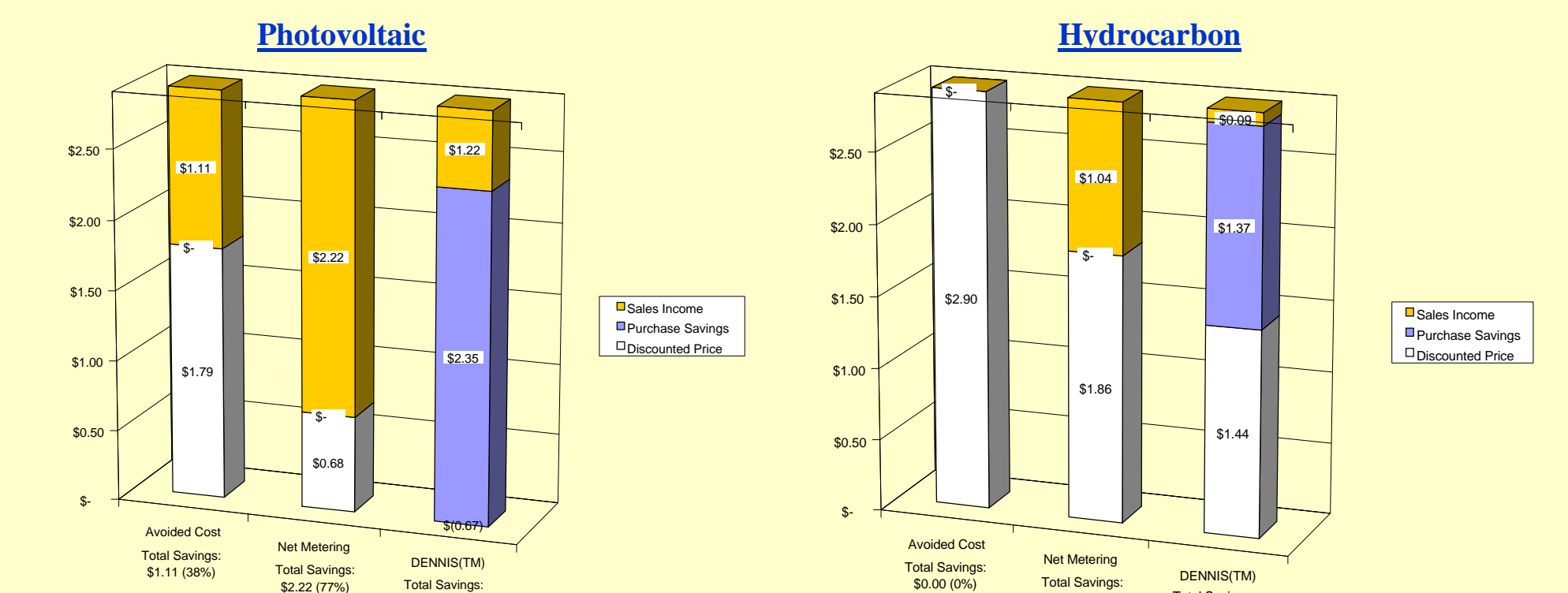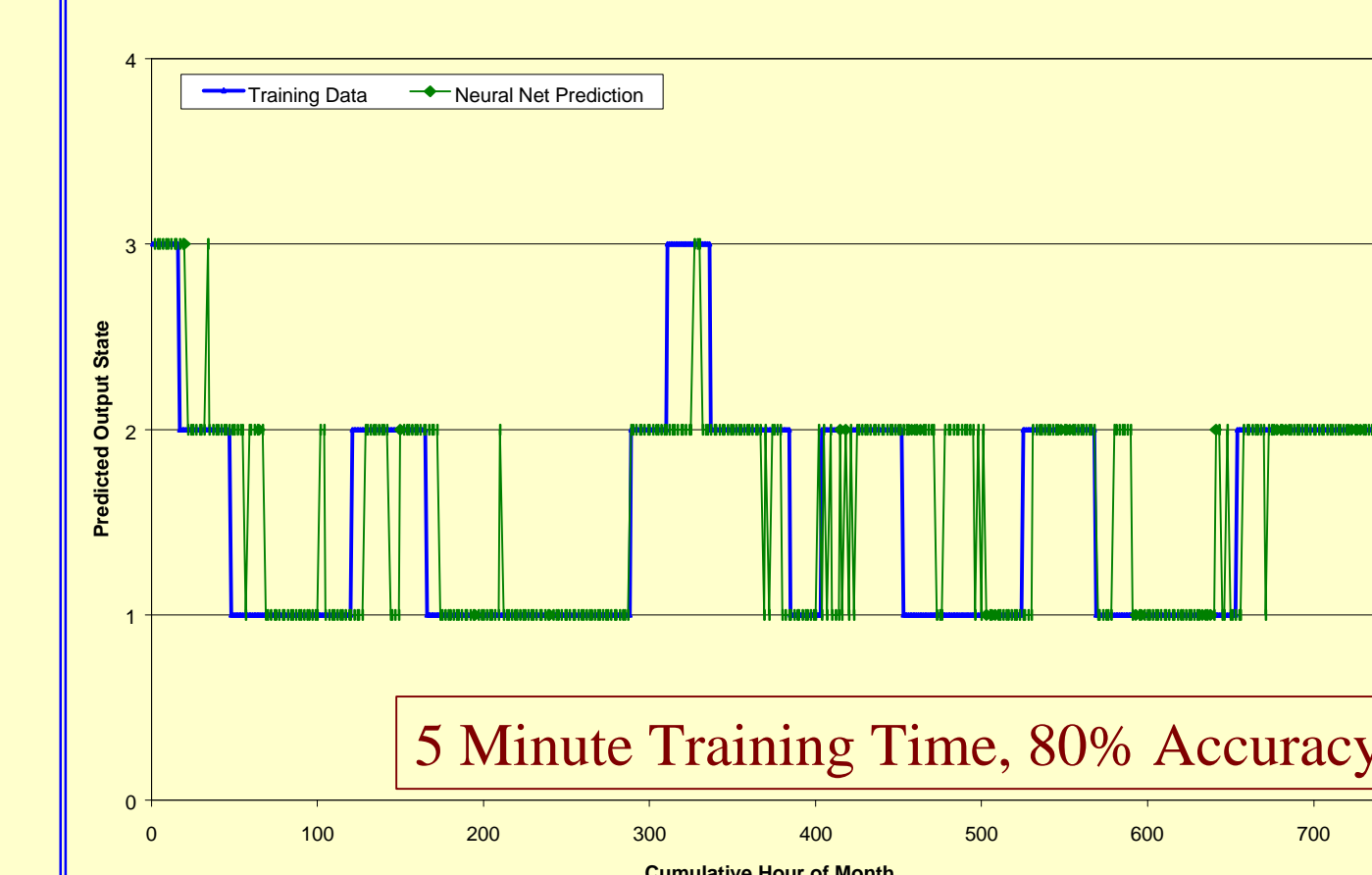
Project Objectives

Develop "next generation" of distributed energy control and integration technology that will enable deployment and coordination of Distributed Power (DP) technologies.

Empower DER owners through autonomous, intelligent and distributed "command and control logic" that will carry out system decision making ensuring efficient, economical, yet safe and reliable dispatch of distributed energy systems.

Major Accomplishments

Orion developed a complete design prototype of DENNIS® based on independent control at the household level and an overall integration strategy for aggregating and coordinating DER.

Programs for all major subcomponents have been developed and tested

Remote DER sites for beta testing have been acquired. Site monitoring for weather, generation and balance of plant are currently underway.

Infrastructure investments and facility upgrades were made at institutional partners DER laboratory, these include: hydrocarbon generation capacity, power switching and data acquisition.

Program focus has transitioned from algorithm development to integration (Code porting/translation and optimization) and testing of DENNIS® hardware and software

Initial Economic Results

Photovoltaic

Hydrocarbon

DENNIS® Savings: 90% to 125%
−35% Better Than Net Metering
−75% Better Than Avoided Cost

DENNIS® Savings: 50%
−15% Better Than Net Metering
−100% Better Than Avoided Cost

Weather Classifying Neural Network

5 Minute Training Time, 80% Accuracy

- Test of basic DENNIS® neural network architecture
- Weather classification based on insolation, temperature, pressure and time of day
- Limited data set for training and testing
- Network successfully classified days as rainy, hazy/rainy or sunny

The DENNIS® neural network adds market prices, power demand, and DG power availability to map measured inputs to sets of control actions

Control Law Generator

Rainy morning eliminates most savings from a grid-tied PV system installed on residence
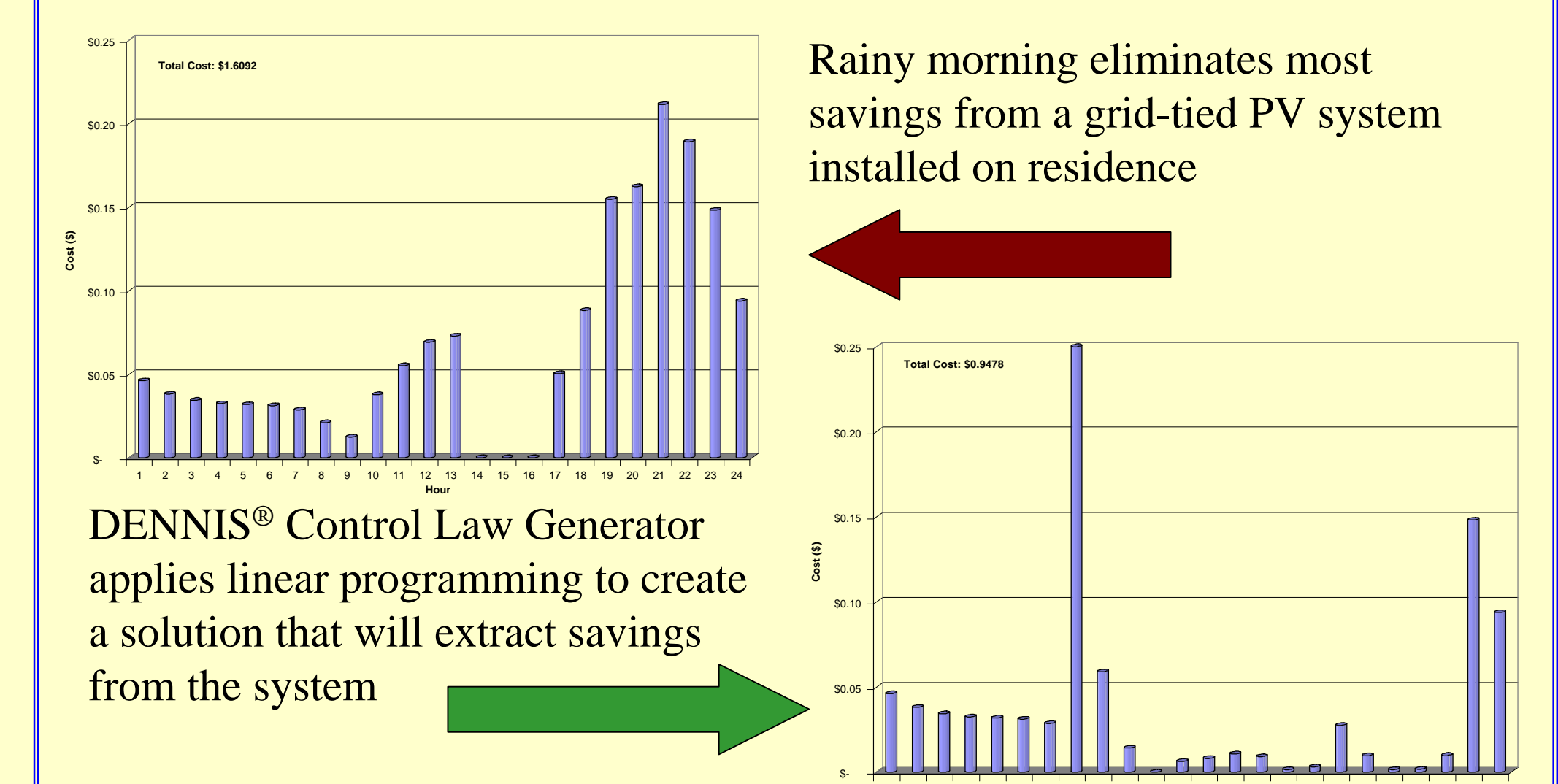
DENNIS® Control Law Generator applies linear programming to create a solution that will extract savings from the system

Cambridge, MA

Full Value for DER

Real Time Pricing (RTP)

Discretionary Control

Aggregation